

A Research onto Study the Properties of Concrete with Partial Replacement of Aggregates by Plastic Aggregates

Paras Kumar Yadav¹, Amit Kumar²

¹Research Scholar, ²Assistant Professor,

^{1,2}Department of CE, B.R.C.M College Of Engineering & Technology, Bahal Bhiwani, Haryana, India

ABSTRACT

Plastic waste management is the main environmental issues in our country. The present study applies to the usage of recycled plastics as an alternative for aggregates in concrete. The motive of the study is to investigate the alteration in the physical qualities of concrete by the use of waste of plastics in concrete.

The utilization of plastic aggregates was discovered to lead to the development of sturdy concrete. Additionally, with the plastics, the tensile and compressive strength of the concrete reduces. The foremost change brought approximately by using plastics is the fact that concrete's thermal conductivity is decreased due to the utilization of plastics. It is able to thus be declared recycled plastics are usually utilized for thermal insulation of structures.

Series of experiments had been performed in this current study for a comparison of the usage of Used Plastic as a replacement of sand in various different proportions. The main conclusions drawn was that the compressive strength increases with the inclusion of Used Plastic upto a certain proportions and then reduces the strength.

How to cite this paper: Paras Kumar Yadav | Amit Kumar "A Research onto Study the Properties of Concrete with Partial Replacement of Aggregates by Plastic Aggregates"

Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-5, August 2020, pp.1633-1639, URL: www.ijtsrd.com/papers/ijtsrd33250.pdf



Copyright © 2020 by author(s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



INTRODUCTION

For several years, research about the utilization of by-products for augmenting the concrete's properties was going on. Recently, efforts were done for the utilization of industry by-products like; glass cullet, GGBS (ground granulated blast furnace slag), silica fume, and fly ash in civil engineering. In concrete the by-products applications are as a replacement of partial aggregate or replacement of partial cement-based upon their grain size as well as chemical composition. In concrete the utilization of this material comes for the safety or these products.

A large focus has been centered on safeguarding and environmental natural resources as well as recycled wastes substances. In fact lots of industries are creating a number of products that include scrap (residues). Within from last twenty years, several types of research regarding the usage of numerous types of urban wastes materials in building components industrials process are published. Several researchers investigate that are already given to learn new sorts of waste materials to explore profoundly certain areas. Additionally, wastes aside from the environmental advantages definitely create consequences that are really good on the attributes of ultimate items.

Among the new waste supplies applied to the concrete industry that is reused clear plastic. For fixing disposal of a great amount of recycled plastic Substances, in concrete industry reuse of plastic material is viewed as probably the

most achievable usage. Recycled plastic may be utilized as rough aggregate of concrete. Nevertheless, it's essential to underline that reusing of byproducts isn't however economically useful, on account of the top expenses of transportation and the effect on the overall expenses of output. Furthermore, it's essential never to overlook various other expenses, specifically referable towards byproducts type, in certain, to the demand of computing gas emission, throughout firing, and also the existence of deadly and contaminating components.

PLASTICS

The term "plastic" indicates material that has plasticity appropriately, something which is created in a gentle condition and utilized in a good state is referred to as a plastic material.

Thus, the foundation of plastic developing may be traced to the processing techniques of all-natural huge polymers for example tortoiseshell, tusks, horns, amber, shellac, lacquer, and inorganic materials like; metals, glass, and clay. Due to organic excessive polymer substances, they aren't even in quality as well as absence mass efficiency in instances that are a number of, coming from first times it's been required particularly in order to process them readily & into greater quality and also to substitute synthetic substances for all-natural huge polymers. Rayon, ebonite, synthetic rubber, and Celluloid are artificial substances. Now, it's identified the

plastics are synthesized huge polymers that happen to have plasticity, as well as consequently materials made from these organic substances, are precluded. Plastics will be divided into 2 kinds. The first category is thermoplastic that could be melted for recycling in plastic industry. These are polyethylene terephthalate, polytetrafluorethylene, polyoxymethylene, polyamide, polypropylene, and polyethylene.

PLASTIC WASTE DISPOSAL

PLASTIC RECYCLING

Recycling is basically a process of recouping old resources from waste materials as well as subsequently including all these similar substances for manufacturing procedures. It is a key problem in today's world. 3 primary recycling reasons are

1. Natural resources can be preserved effectively.
2. Transport is minimized by it and its related costs
3. For waste material large space is needed hence it avoids the space problem..

Chemical modification

Plastic material is reused through synthetic changes or even depolymerization. Depolymerization is obtained in 2 forms as; thermal decomposition (pyrolysis) along with Chemical Decomposition (hydrolysis). For instance, PET is chemically improved to create thermosets polyester, unsaturated polyester, generally utilized in automobile exterior panels, boat hulls, and bathtubs. An additional instance is a thermal decomposition of acrylic waste materials in MMA (methyl methacrylate), a monomer generally utilized in aircraft neon signs as well as windowpanes. The depolymerizing technology for single condensation polymers, for example, polymethyl methacrylate, nylon, polyethylene terephthalate, and urethanes. Nevertheless, it's a lot more complex to chemically alter diverse plastics to create economical and useful chemic feedstock

Mechanical recycling

Mechanical recycling of plastics describes tasks that include granulation or shredding, melting. Plastics should be organized just before mechanical recycling. In order to sort plastics, Technology has been brought automatically utilizing different methods such as flotation, electrostatics, near-infrared and infrared spectroscopy as well as X-ray fluorescence. Plastic is actually possibly melted down immediately as well as molded in a new way, or perhaps melted down after becoming shredded into flakes along with compared to prepare into re-granulate. The physical, as well as chemical properties, have been compared with same substances produced by virgin resins.

Thermal reprocessing

Thermal reprocessing involves warming a thermoplastic at higher temperatures, therefore in order to make the plastic material flow. After cooling down, plastic will be changed in new merchandise. This process doesn't entail the adjustment of chemical plastics structure. For instance, PET, simply being thermoplastic polyester, could be reused as well as heated towards fibers for carpeting, fence posts, and building panels. This particular procedure can't be repeated because repeating might have negative impact on plastic qualities

Literature Review

Batayneh et al. (2017) discovered the impact of terrain plastic material on a concrete slump. Concrete mixes of approximately 20% plastic allergens are equal to changes in fine aggregates. The table shows the detailed results related to slump test as well as mixture proportions. It was noticed that slump is inversely proportional to the content of plastic particles. It also been noticed that slump has reduced to 25% when it is replaced by 20% of the initial slump having 0% plastic particle as revealed in Fig. 2.1. This reduction in value of slump is a result of plastic shape that means the plastic allergens have sharper edges as compared to fine aggregate. At 20% plastic particle content, the value of slump is calculated as 58mm. Therefore, this particular value may be acceptable as well as its mixture is also workable. Additionally, crushed concrete, glass, and plastics had also been utilized as replacing coarse aggregates which have been noticed that using crushed aggregates causes optimum slump minimization, whereas utilizing crushed glass has minimum impact on resulting slump concrete.

Zeng and Bayasi (2014) learned the consequences of polypropylene fibers on the slump as well as inverted slump cone period of concrete mixes. They found that with increase in plastic percentage, inverted slump cone period also increased. It was additionally found that 0.3% is the volume fractions of fibers, fiber impact on workability of fresh mix is irrelevant also quite inconsistent; as well as 0.5% for fiber amount, although, fibers came out to negatively impact new mix workability, much more apparent by the increased inverted slump cone period with nineteen mm fibers with a pronounced impact than 12.7 mm fibers.

Dalal, as well as Al-Manaseer (2012), identified concrete slump mixes produced with plastic aggregates. It was also found that there is increased in concrete slump if plastic-made aggregates have been incorporated. The concrete with 50% plastic material aggregates possessed a somewhat greater cone slump as compared to concrete with no clear plastic aggregates. In addition to the slump test, K slump test had also been performed. Consistency results of K-slump exhibited an equivalent design to which from the cone slump. They realized that the plastic aggregates neither assimilated neither absorbed water. As a result of this particular nonabsorptive attribute, concrete mixes that contain plastic aggregates are going to have much more complimentary water. So, the slump enhanced as revealed in Table 2.2.

Soroshian et al. (2013) claimed a decrease in slump with the usage of recycled plastic material in concrete. Fig.2.2 revealed results of Slump test. It's apparent the inclusion of any discrete reinforcement triggered slump damage. Whereas non slender plastic material particles, residue was shredded by automobile, and flakes have been worn for dosages which had been in order of magnitude of those of slender fibers, the results of theirs on new combination attributes have been similar. This might be due to the pronounced negative effects of slender fibers on new combination workability.

Hoi et al. (2015) investigated the effect of PET bottles WPLA lightweight aggregate on the concrete's workability. Combination ratios of concrete had been designed and so the water-cement proportions were 53%, 49%, and 45%, as well as the WPLA replacing ratio were 75%, 50%, 25%, and 0% by

fine aggregate's volume. They found that slump importance of misuse PET plastic bottles little aggregate concrete (WPLAC) enhanced with the increased replacing and water-cement ratio. The improvement workability ratios show 123%, 104%, and 52%, as compared to normal concrete at 53%, 49%, and 45% of water-cement ratios. This might be linked not only to the smooth and spherical condition but additionally to the absorption of WPLA.

Saradhi et al. (2014) proven fresh concrete with expanded plastics mixes proved much better flow values as compared to the regular concrete at comparable water-cement ratio, as well as absolutely no segregation, was found in virtually any incorporate despite the fact that the concretes were created without having the inclusion of binding ingredients. Besides, it was mentioned that the Expanded Plastics (EPS) aggregates are compressed throughout mixing process as well as the ensuing concrete's densities are usually above the created densities by approximately 50kg/m³ to 100kg/m³. This particular influence was mentioned much more in mixtures that contain the regular rough aggregate.

Elzafraney et al. (2015) realized that higher recycled information concrete made under area problems effectively for the performance needs of this project. Air content ASTM C-231 along with Slump ASTM C-143 mixtures had been assessed. For high-recycled-content along with normal concretes, the slump value was measured as 45mm and 60mm. For high-recycled-content along with normal concretes, air content value had been measured as 10.5% and 6% respectively.

Babu et al. (2014) learned that all of the expanded plastic mixes showed relaxed flow, as well as absolutely no segregation, was found in virtually any incorporate while in the concretes produced without having the inclusion of binding ingredients. Raghvan et al (1998) have claimed that mortars including rubberized shreds attained workability comparable to or even superior to a management mortar with no rubberized debris.

Bayomy and Khatib (2016) investigated the rubcrete's workability as well as stated that with a rise in percentage of rubber content, slump value decreases. The more observed that at 40% rubberized contents, slump was practically zero as well as concrete was not able to work. It had also been found that mixtures produced with fine crumb man-made materials had been much more practical compared to all those with rough tire potato chips or maybe a mix of tire fries as well as crumb man-made materials.

Hashmi, as well as ismail (2017), has discovered the slump is susceptible to reducing sharply with raising the waste plastic ratio as revealed in Fig.2.3. This particular reduction could be due to the point that several contaminants are angular and some have nonuniform styles leading to a lesser amount of fluidity. Despite the slump minimization, the misuse clear plastic concrete mixtures have simple workability and therefore are ideal to be used in huge websites and precast apps depending on the following consideration:

Naik and Siddique (2016) have claimed that mortars including rubberized shreds attained workability equivalent to or maybe superior to a management mortar with no

rubberized debris. It had also been found that mixtures produced with fine crumb man-made materials had been much more workable compared to all those with rough tire potato chips or perhaps a mix of tire fries as well as crumb man-made materials.

DENSITY OF CONCRETE

The concrete's density is analyzed for dry density, fresh density, and bulk density, similarly defined as:

Bulk density

Dalal, as well as Al-Manaseer (2017), examined the outcome of plastic aggregates on the concrete's bulk density. They realized the concrete's bulk density reduced with the increased plastic aggregates articles (Fig. 2.4). The decrease in bulk density has been discovered to be exclusively proportional to plastic aggregates material, concrete density decreased by 13%, 6% and 2.5% for concrete having 50%, 30%, and 10% plastic aggregates. The decrease in density was due to the reduced device plastics weight.

Dry density

Ismail and Hashmi (2018) studied that the dry densities at each curing age tend to increase with increasing the waste plastic ratio in each concrete mixture, but the dry densities tend to increase with time for each concrete mixture at all curing ages. It is clear that at 28 days curing age, the lowest dry density (2223.7 kg/m³) exceeds the range of the dry density for structural lightweight concrete. The use of waste plastic for each curing age reduced the dry densities of all mixtures with increasing the waste plastic ratio,

Scope of present work

In concrete, the utilization of recycled plastics is fairly a new advancement in concrete technology all over the world, as well as large amount of investigation, has to go in before this content is definitely utilized in building that is concrete. In concrete the utilization of plastics lowered the resulting strength of concrete, consequently, the study should be oriented to ternary methods that aid in conquering the disadvantage of using plastics in concrete.

Materials and Methodology

In this study, rubber is used as the partial replacement of coarse aggregate by different amount of percentage. The coarse aggregate is replaced by 10%, 30%, and 40% by the rubber. The materials used for the preparation of concrete

- Cement
- Fine aggregate
- Coarse aggregate
- Plastics Aggregates
- Water

To investigate the properties and suitability of the fine aggregate for the intended application, the following tests were carried out.

- Unit Wt of fine aggregate
- DRY DENSITY

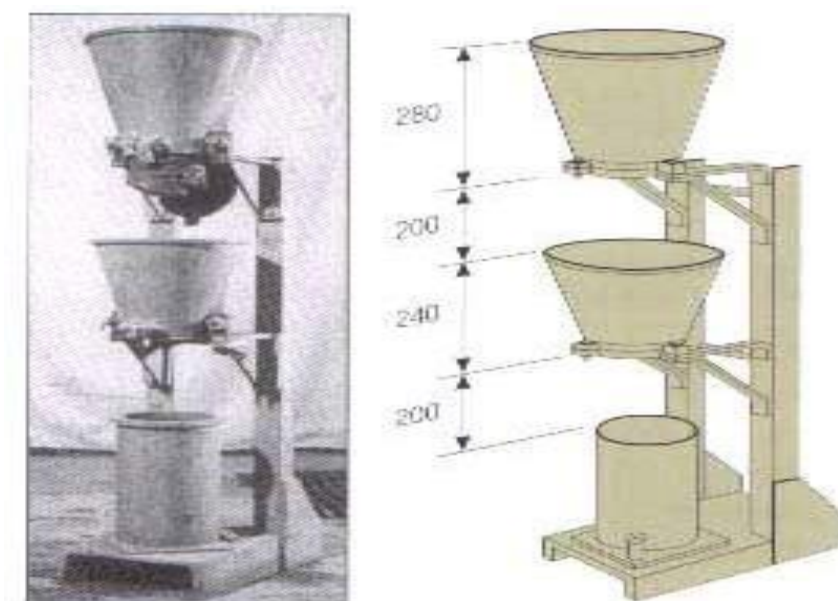
Several test methods will be used to complete this project, these are:

- Compressive strength
- Workability Test
- Split tensile strength Test
- compaction factor test

RESULTS

Workability

The workability of concrete is assessed by compaction factor test the compaction factor test apparatus. the compaction factor test results of controlled mix and plastic added concrete.



Apparatus used for compaction factor test

Compaction factor for the controlled mix

S. No.	W/C ratio	Compaction factor
1.	0.41	0.879
2.	0.42	0.883
3.	0.44	0.895
4.	0.46	0.896
5.	0.48	0.892
6.	0.52	0.894
7.	0.54	0.899

Table Compaction factor for the mix with plastics

S. No.	W/C ratio	Compaction factor
1.	0.41	0.815
2.	0.42	0.853
3.	0.44	0.862
4.	0.46	0.874
5.	0.48	0.888
6.	0.52	0.892
7.	0.54	0.894

Compressive strength test

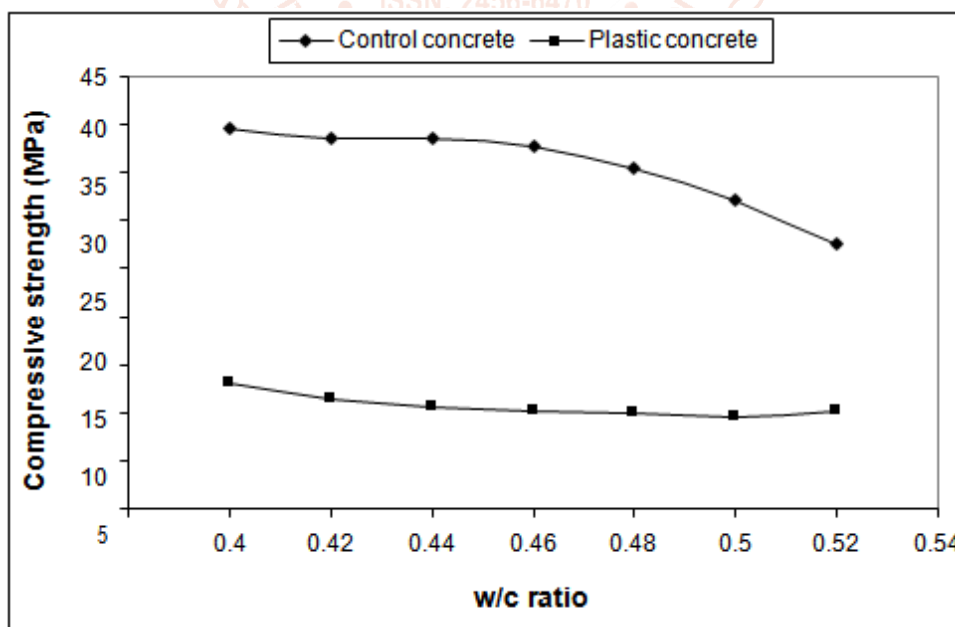
The compressive strength for different water cement ratios of plastic added concrete and control concrete were tested at the end of 28 days using compressive strength testing machine as shown in Plate 4.1. The water cement ratios were taken as 0.4, 0.42, 0.44, 0.46, 0.48, 0.50, and 0.52. Three cubes of each water cement ratio are casted and the average of three test results is taken for the accuracy of the results. The concrete cubes were cured at room temperature. The values of compressive strength obtained are tabulated in Table 4.2 and Fig. 4.2. It is clear from the Fig that with the addition of plastics, the compressive strength of concrete reduces. The average reduction in compressive strength is 70%. This reduction in compressive strength is attributed to the decrease in adhesive strength between the plastic aggregates and the cement paste. Also, it can be seen from the figures that for control concrete, the compressive strength increases with the decrease in water-cement ratio. It is an obvious fact as per Abrams water-cement ratio law, which states that the compressive strength of concrete is inversely proportional to the water-cement ratio of the mix. However, the compressive strength of concrete made with plastic is more or less constant. It can be due to the fact that due to reduction in bond strength between plastics and cement paste, the specimens fail due to failure of bond and water-cement ratio does not play an important role in enhancing strength of plastic concrete. Plates 4.2 and 4.3 respectively show the typical failure patterns of control concrete and plastic concrete.



Plate . Compression testing machine (ACTM)

Compressive strength of control and plastic added concrete

w/c Ratio	Compressive strength (MPa)		Percentage reduction in compressive strength (%)
	control concrete	plastic concrete	
0.40	39.67	13.09	67.00
0.42	38.63	11.39	70.51
0.44	38.47	10.65	74.24
0.46	37.74	10.21	72.94
0.48	35.37	9.96	71.84
0.50	32.11	9.44	70.60
0.52	27.67	10.06	63.64



Graph between water-cement ratio and Compressive strength of control and plastic replaced concrete

SPLIT TENSILE STRENGTH

The split tensile strength for different water cement ratios of plastic added concrete and control concrete is obtained tested at the end of 28 days. The water cement ratios were taken as 0.4, 0.42, 0.44, 0.46, 0.48, 0.50, and 0.52. Split tensile strength of control concrete and plastic concrete

w/c Ratio	Tensile strength (MPa)		Percentage reduction in tensile strength (%)
	Control concrete	Plastic concrete	
0.40	3.98	1.13	71.6
0.42	3.95	1.08	72.7
0.44	3.92	0.8	79.6
0.46	3.77	0.79	79.1
0.48	3.67	0.76	79.3
0.50	3.28	0.75	77.1
0.52	3.04	0.74	75.7

Conclusion

The following would be the conclusions that may be created based on the experiments produced by several researchers:

- Plastics could be utilized in a mixture of concrete to change several aggregates. This plays a significant role in decreasing concrete weight. As an application, it is useful for nonbearing lightweight concrete-like concrete sections employed in facades.
- For a specified w/c, the usage of plastics in the mixture, reduced the density, concrete's tensile strength as well as compressive strength.
- In the plastic concrete case the impact of water-cement ratio is not noticeable. It's due to the reality that the clear plastic aggregates lessen the connect sturdiness of concrete. Thus, the disappointment of concrete happens because of disappointment of the bond between the cement paste and clear plastic aggregates.
- In concrete, plastics introduction tends to create concrete ductile, thus raising the concrete's capability to considerably deform before breakdown. This particular distinctive can make the concrete helpful in situations in which it'll be put through strong temperatures like contraction and development, or maybe thaw and freeze.
- In concrete the addition of reused aggregates under study have been proven to be beneficial by an electricity purpose. The utilization of plastic aggregates useful to keep the inside cooler, if the exterior heat is elevated, as when compared with the control concrete.

References

- [1] Al-Manaseer, A. A., T. R., Dalal, 1997. "Concrete containing plastic aggregates", Concrete International, 47- 52.
- [2] Ashraf, M., Ghaly, F., 2004. ASCE, 1 and Michael S. Gill, A.M.ASCE 2 "Journals of materials in civil engineering" © ASCE, 289-296.
- [3] Balaguru, P. N., Shah, S. P., 1992., "Fiber Reinforced Cement Composites". McGraw- Hill, Inc., 530 p.
- [4] Batayneh, M., Marie, I., Asi I., 2006. "Use of selected waste materials in concrete mixes". Waste Management (27) 1870-1876
- [5] Bayasi, Z., Zeng, J., 1993." Properties of polypropylene fiber reinforced concrete". ACI Materials Journal 90 (6), 605-610.
- [6] Benazzouk, A., Queneudec, M., 2002. "Durability of cement-rubber composites under freeze thaw cycles". Proceedings of the International Conference on Sustainable Concrete Construction, University of Dundee, Scotland, UK, pp. 356- 362
- [7] Boutemour, R., Taibi, M., Ouhib, N., Bali, A., 2004. "Investigation of the use of waste plastic as aggregate for concrete" In: International Conference, Sustainable Waste Management and Recycling: Challenges and Opportunities, 14-15. Thomas Telford Publishing, Thomas Telford Ltd., London, ISBN 0727732854.
- [8] Cheong, K. H. and Lee, S. C., 1993. "Strength of Retempered Concrete", ACI Materials J. 90 (3), 203-206
- [9] Choi, Y.W., Moon, D.J., Chung, J.S., Cho, S.K., 2005. "Effects of waste PET bottles aggregate on properties of concrete". Cement and Concrete Research 35, 776-781.
- [10] Eldin, N. N., 1993 Member, ASCE, and Ahmed B. Senouci, 2 Associate Member, ASCE., "Rubber-tire particles as concrete aggregates". Journal of Materials in Civil Engineering, Vol. 5, No. 4
- [11] Fattuhi, N. I., Clark, N. A., 1996. "Cement-based materials containing tire rubber". Journal of Construction and Building Materials 10 (4), 229-236.
- [12] Goulias, D. G., Ali, A. H., 1997. "Non-destructive evaluation of rubber modified concrete". In: Proceedings of a Special Conference, ASCE, New York, pp. 111-120.
- [13] Hernandez-Olivares, F., Barluenga, G., Bollati, M., Witoszek, B., 2002. " Static and dynamic behavior of recycled tire rubber-filled concrete". Cement and Concrete Research 32 (10), 1587-1596.
- [14] Jain, R. K., Singh, Y., Rai, Mohan., 1977., "Recent Trends of Research in Plastic Building materials in India". Building and Environment, Vol. 12, pp. 277-280
- [15] Jo, B. W., Park, S. K., Park, J. C., 2007. "Mechanical properties of polymer concrete made with recycled PET and recycled concrete aggregates". Construction and Building Materials
- [16] Karim, S., Rebeiz, D., Fowler, W., Fellow, and Donald R. P., 1993. "Recycling plastics in polymer concrete for construction applications". Journal of Materials in Civil Engineering, Vol. 5, 237-248.
- [17] Khatib, Z. K., Bayomy, F. M., 1999. "Rubberized portland cement concrete" ASCE Journal of Materials in Civil Engineering 11 (3), 206-213.
- [18] Kline, C. (1989). "Plastics recycling take off in the USA." Chem. & Industry, 4(July), 440-442.
- [19] Mehta, P. K., Monteiro, P.M., 1993. Concrete: Structure, Properties, and Materials. Prentice Hall, 549
- [20] Naik, T. R., Singh, S. S., Brodersen, B. S., 1996. "Use of post-consumer waste plastics in cement-based

- composites". Cement and Concrete Research 26, 1489–1492.
- [21] Marzouk, O. Y., Dheilily R. M., Queneudec, M., 2007. "Valorization of post-consumer waste plastic in cementitious concrete composites". Waste Management (27) 310–318.
- [22] Marzouk, Y.O., 2005. "Valorisation of plastic bottle waste in cementitious concrete". Doctoral dissertation, University of Picardie Jules Verne, Laboratory of Innovative Technologies, EA 3899, Amiens, France.
- [23] Panyakapo. P., Panyakapo. M., 2007. "Reuse of thermosetting plastic waste for lightweight concrete." Waste Management.
- [24] Raghvan, D., Huynh, H., Ferraris, C. F., 1998. "Workability, mechanical properties and chemical stability of a recycled tire rubber-filled cementitious composite". Journal of Materials Science 33 (7), 1745–1752.
- [25] Saradhi Babua, D. T, Ganesh Babub, K. T.H. Wee., 2005. "Properties of lightweight expanded polystyrene aggregate concretes containing fly ash". Cement and Concrete Research (35) 1218–1223.
- [26] Siddique, R., Naik, T. R., 2004. "Properties of concrete containing scrap-tire rubber – an overview". Waste Management (24) 563–569.
- [27] Soroushian, P., Mirza, F., Alhozaimy, A., 1995. "Permeability characteristics of polypropylene fiber

